Not to be cited without prior reference to the author

ICES C.M. 1995 C.M. 1995/L:21

SPATIAL-TEMPORAL FLUCTUATIONS OF PHYTOCENE IN THE SOUTH BALTIC SEA DURING FALL AND SPRING

by

Semyonova S.N., Feldman V.N., Kostikova T.A.
Atlantic Scientific Research Institute of Marine Fisheries and Oceanography (AtlantNIRO), 5, Dm.Donskoy Str., Kaliningrad, 236000, Russia

ABSTRACT

The paper presents the results of phytoplankton observations performed in the Southern Baltic Sea during October 1992 and March 1993. During the observation period 115 species and intraspecific taxons belonging to 6 sections and one general group of Flagellata. Maximum number of species was observed in October (91 species and subspecies). In October the researches were performed during the extinction period after the fall peak of phytoplankton development. During the above period the bulk of phytoplankton consisted of Flagellata, Diatoms, Protococctieae, Bacillariophyta, Chrysophyta, Euglenophyta, as well as Cyanophyta and Cryptomonadinae. In March diatoms predominated in phytoplankton algae and Sceletonena costatum predominated among the latter. The major phytoplankton aggregations was observed in the layer of 0-25 m. However, while in fall the major vegetation occurred in the layer of 0-5 m, in spring the depth of the peak abundance indices shifted to 25 m. As a rule the spring intense development of phytoplankton is observed in the coastal zone. In fall the zone of active vegetation extended into the open sea. Algae development and distribution indicated the organic pollution of the sea, particularly in the coastal zone southwards of 56°W.

INTRODUCTION

At present the problem of the Baltic Sea pollution due to anthropogenic impact is considered one of the most serious ecological problems.

Monitoring of seasonal phytoplankton development in the Baltic Sea is a purpose of complex researches performed by AtlantNIRO in the South Baltic Sea (Semyonova et al., 1993).

MATERIAL AND METHODS

Two complex surveys were carried out to study phytoplankton, one from 23 October to 4 November 1992 and the second from 21 to 27 March 1993.

Sampling was performed with bathometer from the depths of 0, 5, 10, 25, 50, 75 and 100 m. Samples were thickened with one-stage reverse filtration through a nuclear filter with pore diameter of 1 μ, and were subsequently fixed in 40% formaline, neutralized with KOH (Kiseliev, 1956; Semyonova, 1985, Sorokin, 1975). Identification and count of algae was performed using a microscope on a glass plate in a drop of 0.05 cub.cm in volume. During material treatment algae were counted to calculate average volume by means of comparison of live forms to simple geometrical forms (Kiseliev, 1956). Biomass was estimated by means of species abundance multiplying by its average volume. In species of Cyanophyta group the number of trichomes and colonies was counted; innalgae of p.p.Scenedesmus, Coelastrum, Pediastrum belonging to Protococcineae class and Chlorophyta group the number of cenobies was counted, in others - the cell number. Totally 411 samples were collected during investigation period. Main parameters of phytoplankton development were estimated at computer EC-1033.

RESULTS AND DISCUSSION

During the observation period species composition of the Baltic Sea phytoplankton was represented by 115 species and intraspecies taxons, belonging to 6 orders and to complex group of Flagellatae (Table 1). The bulk of floristic spectrum consisted of Chlorophyta (36 species and varieties), Pyrrophyta (28 species and varieties), Bacillariophyta (24 species and varieties) and Cyanophyta (11 species and varieties). Other groups were represented by less number of taxons. The maximum qualitative diversity within chlorophyta was observed in the class of Protococcianeae (29 species and varieties), within Pyrrophyta - in Peridineae (25 species and varieties), and within Bacillariophyta - class of Centriceae (19 species and varieties). The most diversified species were Scenedesmus in Protococcineae class, Gymnodinium and Peridinium in Peridineae class, Chaetoceros in Centrioaea class. During the observation period diversity and ratio of taxonomic groups was changed. Thus maximum algae number was observed in October (91 species and varieties). In respect of species number Protococcineae predominated during the period (26 species and varieties), followed by Peridineae (18 species and varieties) and Bacillariophyta (14 species and varieties). In March the total species number decreased by 1.6 times. Bacillariophyta (17 species and varieties), Peridineae (12 species and varieties) and Protococcineae (11 species and varieties) predominated qualitatively.

In fall quantitative indices of phytoplankton were defined by development of Coscinodiscus granii Gough, Cyclotella comta (Ehr.) Kütz, Flagellatae, Oocystis submarina Lagerh., Kirchneriella irregularis (Smith) Korschik., Eutreptia lanovii Seuer, Dinophysis acuta Ehr., Goniaulax catenata (Lev.)Kof., Aphanizomenon flos-aguae (L.) Ralfs, Microcystis pulverea (Wood) Forti cm.Elenk., Cryptomonas baltica (Karst.) Butch., Cryptomonas pelagica (Lohm) Butch., while in spring major species were Sceletonema costatum (Grev.)Cleve, Thalassiosira baltica (Grun.in Cl.et Grun.)Ost., Coscinodiscus granii Gough, Goniaulax catenata (Lev.)Kof.

October survey showed that during observation period phytoplankton was in the state of postmaximum fall development (Nikolayev, 1985). A vegetation level pof phytoplankton was not high, averaged to 19.857 mln.cells$\cdot m^{-3}$ (Table 2). High algae abundance was observed only in south-western part of the investigation area (91.66 mln. cells$\cdot m^{-3}$, Fig. 1A). In other parts of area abundance indices varied from 4.48 to 40.02 mln.cells$\cdot m^{-3}$. In the coastal area southward of Klaipeda the abundance value was below 9.02 mln.cells$\cdot m^{-3}$ Besides, 2 localities of poor phytoplankton development were found in the northern and western parts of the investigation area.

In October total phytoplankton abundance was represented by Bacillariophyta, Flagellatae, Protococcineae, Euglenophyta, Chrysophyta, Cyanophyta and Cryptomonadinea.

In Bacillariophyta the cells number varied from 1.2 to 14.2 mln. cells$\cdot m^{-3}$. Average abundance amounts to 4.0 mln.cells m^{-3} or 20.2% of total phytoplankton, Peak abundance was observed off Venspils (Fig. 1B). Vegetation of Diatomes was defined by development of large-sized Coscinodiscus granii Gough.and small-sized Cyclotella comta (Ehr.) Kütz.

Unlike Bacillariphyta, distribution of Flagellatae is characterized by relative unregularity (Fig. 1C). Algae development was weak (0.2-9.79 mln. cells$\cdot m^{-3}$), excluding south-western part of the area where a higher abundance was observed (73.5 mln.cells$\cdot m^{-3}$) associated to the location of total phytoplankton peak abundance.

Development of Chrysophyta, Protococcineae and Euglenophyta was 1.5 times less than that of Bacillariophyta and Flagellatae. Their average abundance was 2.39, 2.28 and 2.24 mln. cells$\cdot m^{-3}$ respectively (Fig. 1 D, E, 7).

Cyanophyta and Cryptomonadineae contributed the total abundance insignificantly. In average Cyanophyta represented 9.4% and Cryptomonadineae 8.1% of total phytoplankton abundance. Average cells number amounts to 1.8 and 1.6 mln.cells$\cdot m^{-3}$ respectively. Distribution was extremely unregular. Total phytoplankton biomass was relatively high.

Average biomass was 879.845 mg.m^{-3} (Table 3). Algae biomass increases above a thousand mg.m^{-3} was observed in the central sea area (Fig. 2A). The maximum sea phytoplankton biomass (3.2g$\cdot m^{-3}$) was observed in the same area.

Unlike abundance, the total algae biomass almost entirely depended on Bacillariophyta distribution (Fig. 2B), constituted in average 790.059 mg.m^{-3} or 89.8% of the total biomass. Coscinodiscus granii Gough was the most abundant (99% of biomass) species within Bacillariophyta (Fig. 2C). Large concentrations of Bacillariophyta were observed in the central part of the area, similar to the total biomass of phytoplankton. Peak values (up to 3.19g.m^{-3} were found inthe southern part. In October high abundance indices of algae were found in the layer of 0.5 m with maximum at 5 m depth (Fig. 3A, B, C, D, E, F; 4A, B, C).

In March phytoplankton development increased by 2.7 items as compared to that in October which was mainly stipulated by algae vegetation with a coastal area. Total phytoplankton abundance varied from 7.08 to 172.28 mln. cells$\cdot m^{-3}$. Maximum abundance was observed off the Baltic Spit (Fig. 5A). A patch of high abundance (up to 124.1 mln. cells$\cdot m^{-3}$) was found off the village of Donskoye. Major phytoplankton concentrations (above 50.0 mln. cells$\cdot m^{-3}$) occured in the coastal zone. In the north of the area total algae abundance was about 7.1 mln. cells$\cdot m^{-3}$.

Bacillariophyta constituted 75.14% of the total phytoplankton abundance. Average algae abundance approached 39.73 mln. cells$\cdot m^{-3}$ while absolute indices varied from 6.18 to 159.22 mln. cells$\cdot m^{-3}$. In general spatial distribution of Bacillariophyta was similar to the total phytoplankton distribution (Fig. 5B). High concentrations (above 50.0 mln. cells$\cdot m^{-3}$) of Bacillariophyta similar to the total abundance, occured within the coastal zone while the peak abundance (159.2 mln. cells$\cdot m^{-3}$) was observed off the Baltic Spit. Algae had a typical sea distribution. High abundance was observed near the coast. In the off-shore areas the abundance was decreasing gradually. Within Bacillariophyta the small-cell Sceletonema costatum (Grev.) Cleve predominated (average abundance 19.87 mln.cells$\cdot m^{-3}$). Northward of the Baltic Sea the latter species development gradually decreased from 85.8 mln.cells$\cdot m^{-3}$ to 0.4 mln.cells$\cdot m^{-3}$. The north-western part of the area represents the only exception (34.9 mln.cells$\cdot m^{-3}$).

Besides Bacillariophyta, Peridineae also contributed considerably the total phytoplankton abundance within individual areas (from 0.44 to 24.02 mln.cells$\cdot m^{-3}$). Average abundance of the latter amounted to 8.5 mnl.cells$\cdot m^{-3}$. Vegitation of Peridineae (Fig.5C) was almost entirely defined by the development of Antarctic species of Goniaulax catenata (Lev.) Kof. with average abundance 7.6 mln. cells$\cdot n^{-3}$.

Since in March unlike October, mainly middle- and small-size algae predominated in phytoplankton, average weighted volume of cells was almost 10 times less than that in October. It resulted in decrease of both absolute (up to 680.0 mg.m^{-3}) and average biomass (209.8 mg.m^{-3}). At the background of relatively regular (from 100 to 500 mg.m^{-3}) distribution (Fig. 6A) the area off the Baltic Spit was characterized by high biomass concentrations (681.3 mg.m^{-3}) In the central and north-western areas indices decreased to 83.9 mg.m^{-3} and 58.3 mg.m^{-3} respectively.

Total phytoplankton biomass distribution depended on development of dominated species such as Bacillariphyta with average biomass of 124.67 mg.m^{-3}or 59.4% of the total biomass. Peridineae with average biomass of 59.83 mg.m^{-3} contributed considerably the total biomass.

Major concentrations of Bacillariophyta (above 100.0 mg.m^{-3}) were found along the coast and north-eastwards of the coast (Fig. 6B). In the area off the Baltic Sea the peak biomass (573.2 mg.m^{-3}) was observed. It should be noted that while in coastal zone Bacillariophyta biomass depended mainly on development of Thalassiosira baltica (Grun. in Cl. et Grun.) Ost. , in the north-eastern part of open area it was defined by vegetation of Coscinodiscus granii Gough.

Biomass indices of Peridineae varied from 1.5 to 173.6 mg.m^{-3}. Biomass concentrations above 50.0 mg.m^{-3} occured within the coastal zone (Fig. 6C).

In March phytoplankton vertical distribution pattern was unlike that in October. Maximum abundance was observed in the layer of 10-25 m. Average abundance indices were similar: 55.19 mln.cells$\cdot$m^{-3} at the depth of 10 m and 54.7 mln.cells$\cdot$m^{-3} at the depth of 25 m. respectively. The highest biomass was recorded at the depth of 25 m (average 260.186 mg.m^{-3}) (Fig. 7A, B, C, 8A, B, C).

CONCLUSION

The results of study reveiled that October surveys occured in the extinction after the fall peak which was evidenced by species composition and level of phytoplankton development. Average cells number within the layer of 0-25m amounted to 19.8 mln.cells$\cdot$m^{-3}. Qualitative indices were defined by Flagellatae, Bacillariophyta, Protococcineae, Chrysophyta, Euglenophyta, Cyanophyta and Cryptomonadineae. Due to development of large-size (above 10^{4} μm^{3}) Bacillariophyta, the total biomass was high (879.845 $mg.m^{-3}$ in average).

In spring structural reconstruction occured in phytocene. It was represented by strong vegetation, change of algae taxonomic groups ratio and specific compostion. The level of Bacillariophyta development in March was 9.9 times higher than that in October. Algae of the above order predominated in phytoplankton small-size (less than $10^3 \mu m^3$) species were dominating (30.378 $mln.cells.m^{-3}$ in average), and centric early-spring species Sceletonema costatum (Grev.) Cleve predominated within the latter (19.872 $mln.cells.m^{-3}$ in average). As compared to October, proportion of small Bacillariophyta increased by 19.2 times, that of middle-size by 14.9 times and large-size by 2.2 times. Due to domination of small algae in March the total biomass in the layer of 0-25 m decreased by about 4.2 times as compared to that in October, and amounted to 209.8 $mg.m^{-3}$

Major phytoplankton development during the observation period occured in the layer of 0-25 m. However, peak abundance indices were found at various depth of the above-mentioned layer in relation to seasons. In October the highest algae development was observed above thermocline within 0-5 m. During March in the absence of temperature shift layer, the depth of peak phytoplankton abundance indices increased to 25 m.

As a rule, strong algae development in March occured in the coastal zone. In October area of active phytoplankton vegetation extended into the open sea.

REFERENCES

Kiseliev I.A. 1956. Methods of phytoplankton researches//Life of fresh waters in USSR. M-L.AS USSR, 1956,vol.4,p.183-265.

Nikolayev I.I. 1985. Biological seasons of the Baltic Sea//Trudy VNIRO (Latvian Department), 1985,vol.2,p.115-140.

Semyonova S.N. 1985. Phytoplankton succession in the Eastern area of subantarctic and antarctic Atlantic ocean//Complex study of biproduction in the South Ocean:Trudy VNIRO,-M,1985,vol1, p.158-173.

Semyonova S.N., Krasovskiy I.V., Zezera A.S. and V.N.Feldman.1993. Spatial structure of phytocene in the Baltic Sea in May 1992// C.M.1993/L:27 Ref.J.

Sorokin Yu.I. 1975. Heterotrophic microplankton as a component of marine ecosystems//General Biology Yournal - 1976 -vol.36, No.5, p.716-730.

Table 1

Fluctuations of phytoplankton species composition in the Baltic Sea

No.	Taxon	1992 October	1993 March	Total
1.	order Chrysophyta	6	4	7
	order Pyrrophyta	21	13	28
2.	class Cryptomonadineae	3	1	3
	class Peridineae	18	12	25
3.	order Euglenophyta	5	1	5
4.	complex group Flagellatae	3	3	4
	order Chlorophyta	33	13	36
	class Volvocineae	5	1	5
5.	class Protococcineae	26	11	29
	class Ulothrichineae	1	1	1
	class Conjugateae	1	–	1
6.	order Bacillariophyta	14	17	24
7.	order Cyanophyta	9	7	11
	Total	91	58	115

Table 2

Average abundance (mln.cells·m^{-3}) of phytoplankton within 0-25 m in the South Baltic Sea during October 1992 and March 1993

Month year	Chrysophyta	Pyrrophyta			Euglenophyta	Flagellatae	Chlorophyta				Xanthophyta	Bacillariophyta	Coscinodiscus granii	Skeletonema costatum	Cyanophyta	Total
		Cryptomonadineae	Peridineae	Goniaulax catenata			Volvocineae	Protococcineae	Conjugateae	Ulothrichineae						
X.92	2.391	1.603	0.870	0.436	2.241	4.290	0.316	2.281	-	-	-	4.005	1.641	0.199	1.859	19.857
III.93	2.237	0.055	8.527	7.578	0.310	0.445	0.122	1.073	-	0.055	-	39.735	0.044	13.872	0.329	52.889

Table 3

Average biomass (mg.m^{-3}) of phytoplankton within 0-25 m in the South Baltic Sea during October 1992 and March 1993

Month year	Chrysophyta	Pyrrophyta			Euglenophyta	Flagelatae	Chlorophyta				Xanthophyta	Bacillariophyta	Coscinodiscus granii	Cyanophyta	Total
		Cryptomonadineae	Peridineae	Goniaulax catenata			Volvocineae	Protococcineae	Conjugatae	Ulothrichineae					
X.92.	25.869	2.086	34.920	3.154	1.151	0.750	0.058	2.150	-	-	-	790.059	782.467	22.802	879.845
III.93	21.040	0.006	59.835	54.777	0.148	0.073	0.027	1.212	-	0.222	-	124.672	20.910	2.566	209.802

LEGENDS

Figure 1. Distribution of total phytoplankton and major groups abundance (mln.cells$\cdot m^{-3}$) in the layer of 0-25 m in the Southern Baltic Sea during October 1992:
A - total phytoplankton; B - Bacillariophyta;
C - Flagellatae; D - Protococcineae;
E - Euglenophyta; F- Chrysophyta.

Figure 2. Total phytoplankton and groups biomass (mg.m^{-3}) distribution in the layer of 0-25 m in the Southern Baltic Sea during October 1992:
A - total phytoplankton; B - Bacillariophyta;
C - Coscinodiscus granii Gough.

Figure 3. Distribution of total phytoplankton and groups abundance (mln.cells$\cdot m^{-3}$) at the depth of 5 m in the Southern Baltic Sea during October 1992:
A - total phytoplankton; B - Bacillariophyta;
C - Flagellatae; D - Protococcineae;
E - Euglenophyta; F - Chrysophyta.

Figure 4. Total phytoplankton and groups biomass distribution (mg.m^{-3}) at the depth of 5 m in the Southern Baltic Sea during October 1992:
A - total phytoplankton; B - Bacillariophyta;
C - Coscinodiscus granii Gough.

Figure 5. Distribution of total phytoplankton and groups abundance (mln.cells$\cdot m^{-3}$) in the layer of 0-25 m in the Southern Baltic Sea during March 1993:
A - total phytoplankton; B - Bacillariophyta;
C - Peridineae;

Figure 6. Distribution of total phytoplankton and major groups biomass (mg.m^{-3}) in the layer of 0-25 m in the Southern Baltic Sea during March 1993:
A -total phytoplankton; B - Bacillariophyta;
C - Peridineae.

Figure 7. Distribution of total phytoplankton and major groups abundance (mln.cells$\cdot m^{-3}$) at 25 m in the Southern Baltic Sea during March 1993:
A - total phytoplankton; B - Bacillariophyta;
C - Peridineae.

Figure 8. Distribution of total phytoplankton and major groups biomass ($mg.m^{-3}$) at 25 m in the Southern Baltic Sea during March 1993:

A - total phytoplankton; B - Bacillariophyta;

C - Peridineae .

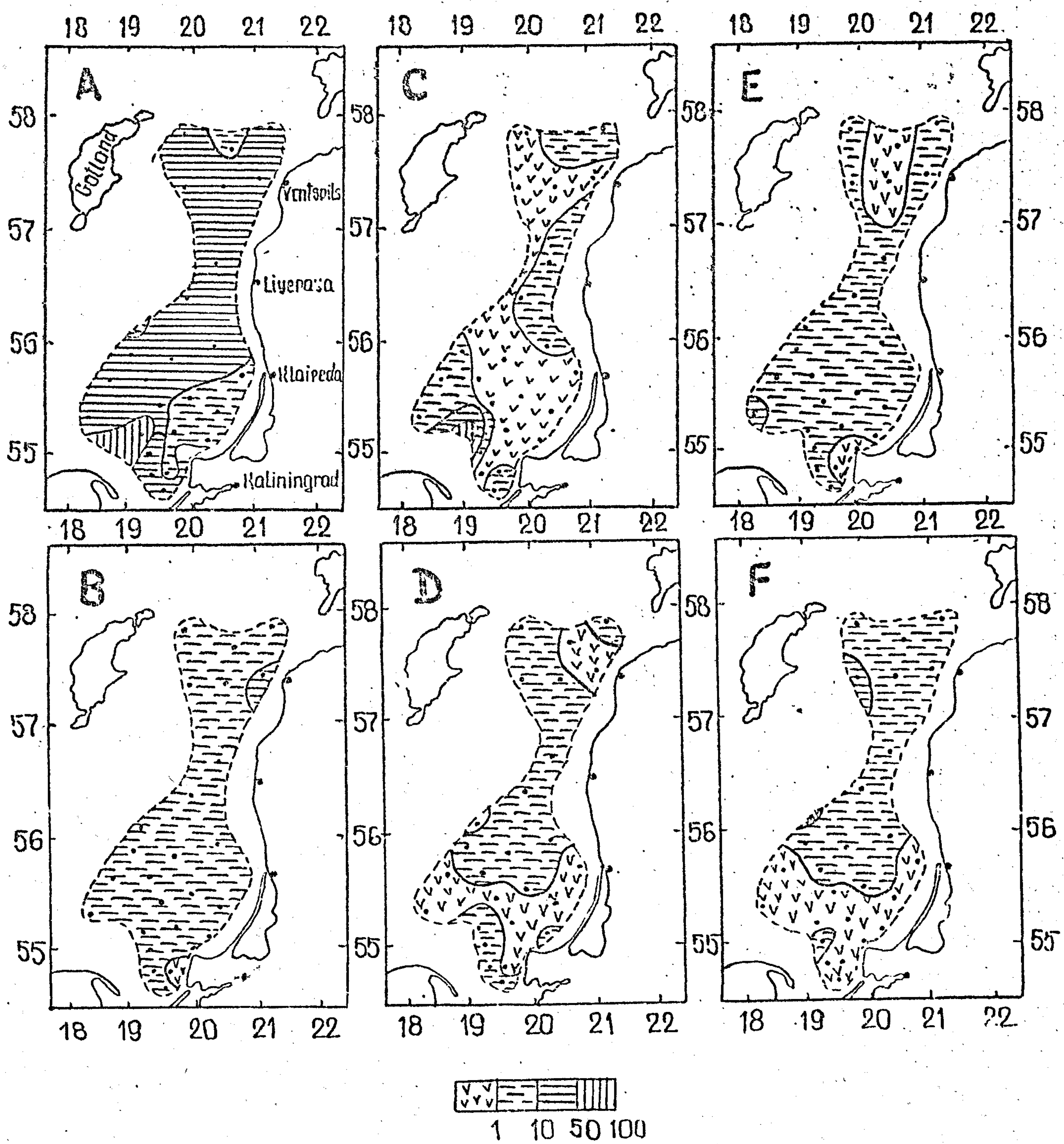
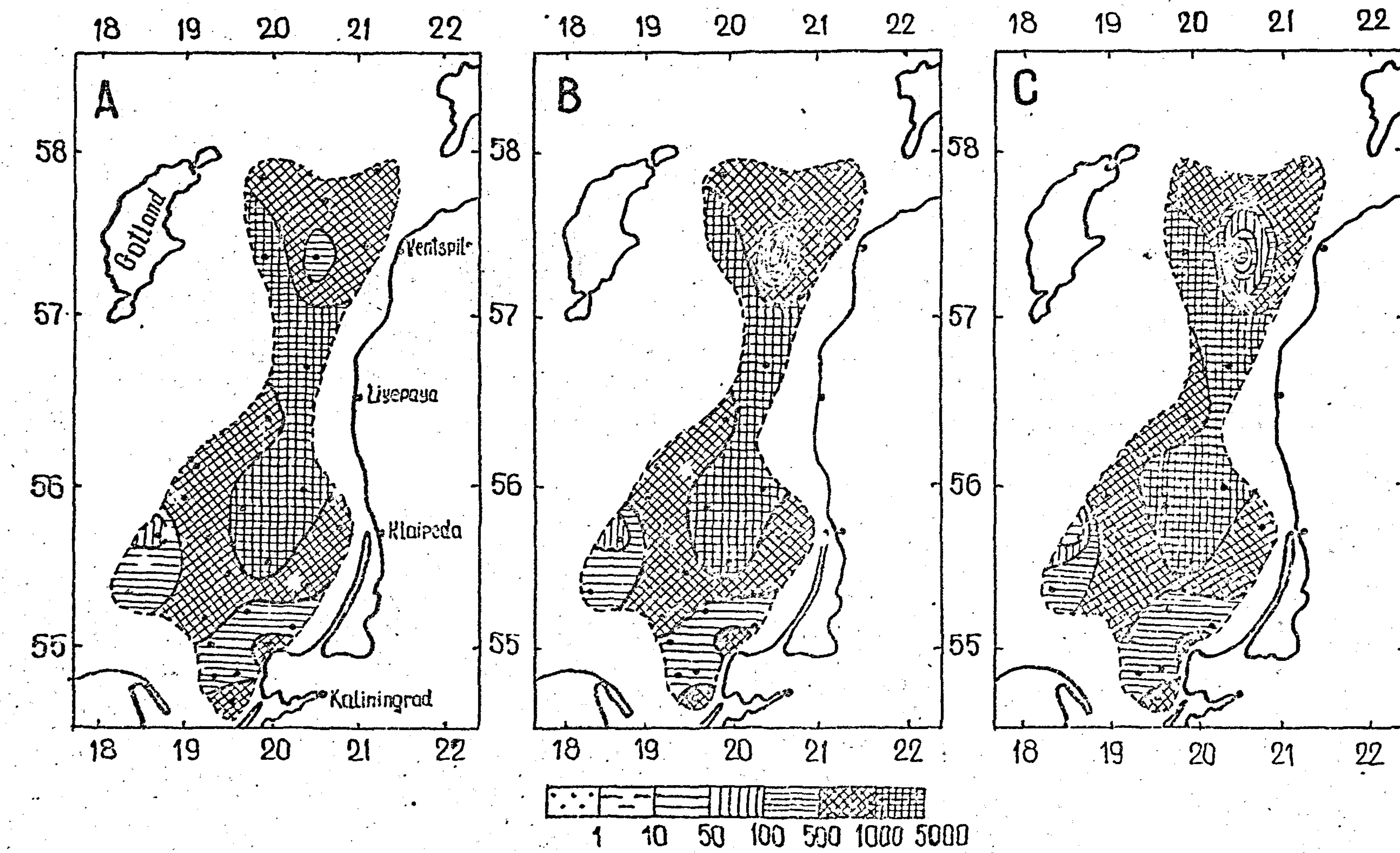

A
B
C
D
E
F
Gotland
Ventspils
Liyepaja
Klaipeda
Kaliningrad
18 19 20 21 22
55 56 57 58
1 10 50 100

Fig.1



A
B
C
Gotland
Ventspils
Liyepaya
Klaipeda
Kaliningrad
18 19 20 21 22
58 57 56 55
1 10 50 100 500 1000 5000

Fig.2

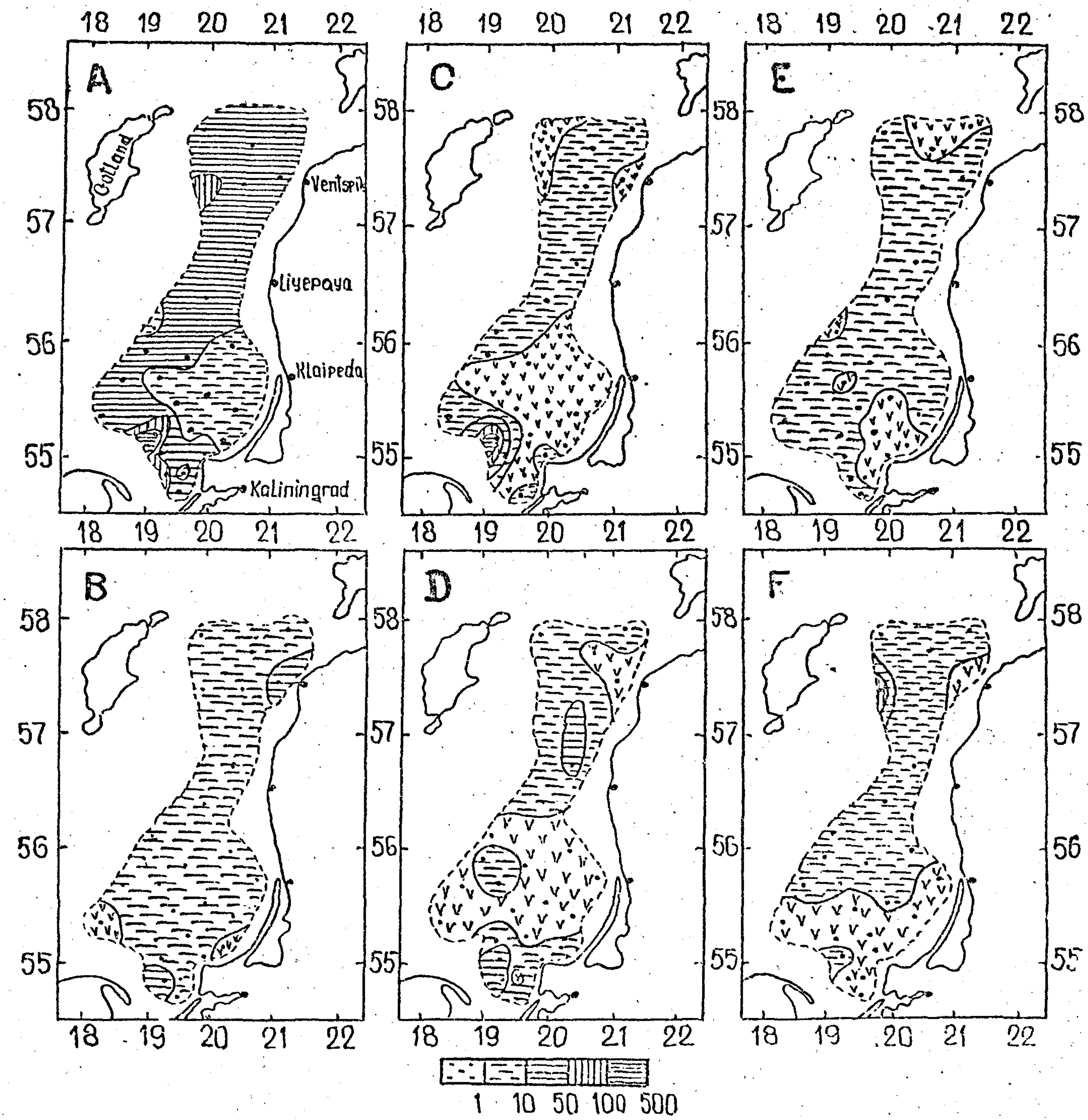

A
B
C
D
E
F
Gotland
Ventspils
Liyepaya
Klaipeda
Kaliningrad
18 19 20 21 22
55 56 57 58
1 10 50 100 500

Fig.5

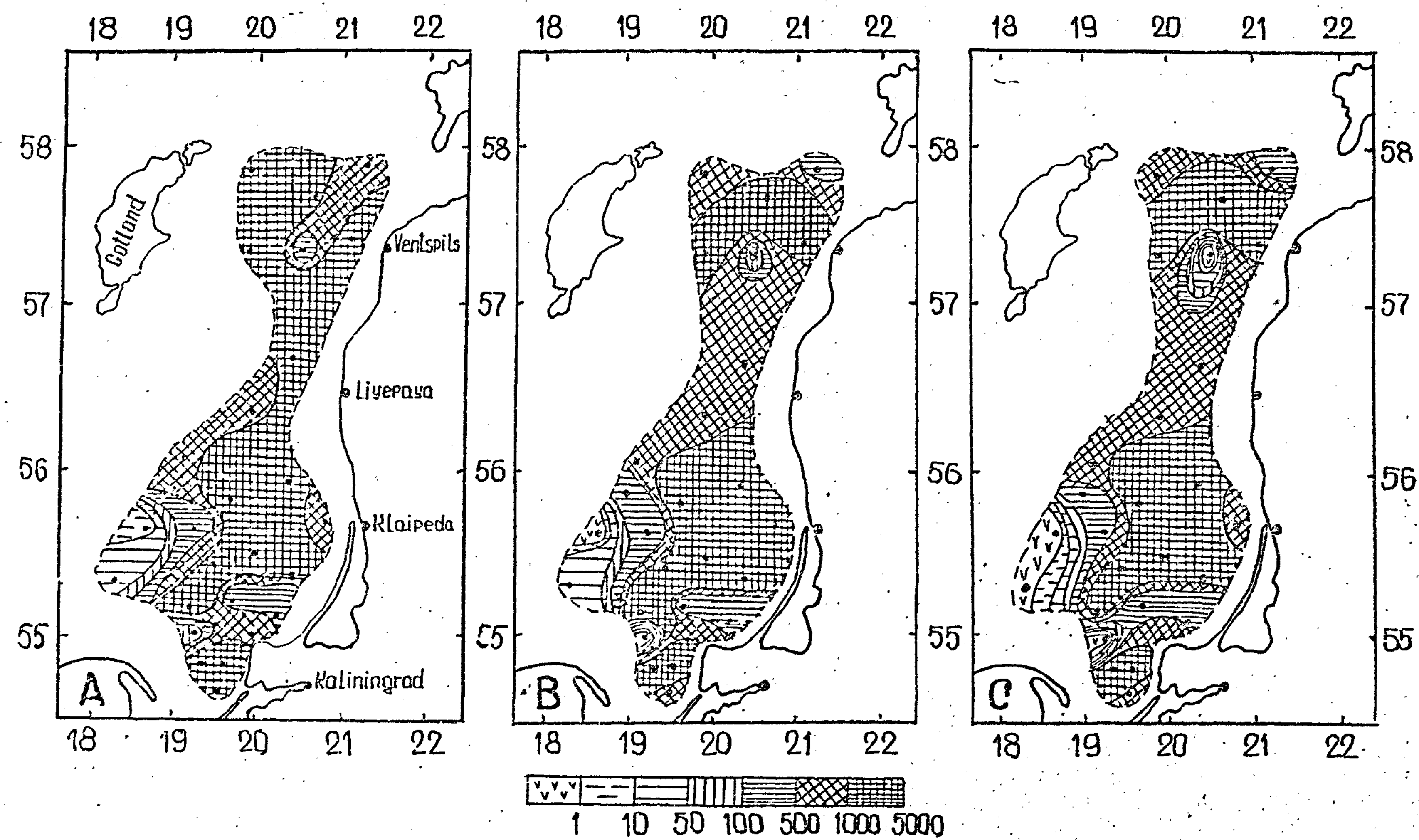

Gotland
Ventspils
Liyepaya
Klaipeda
Kaliningrad
A
B
C
18 19 20 21 22
58 57 56 55
1 10 50 100 500 1000 5000

Fig.4

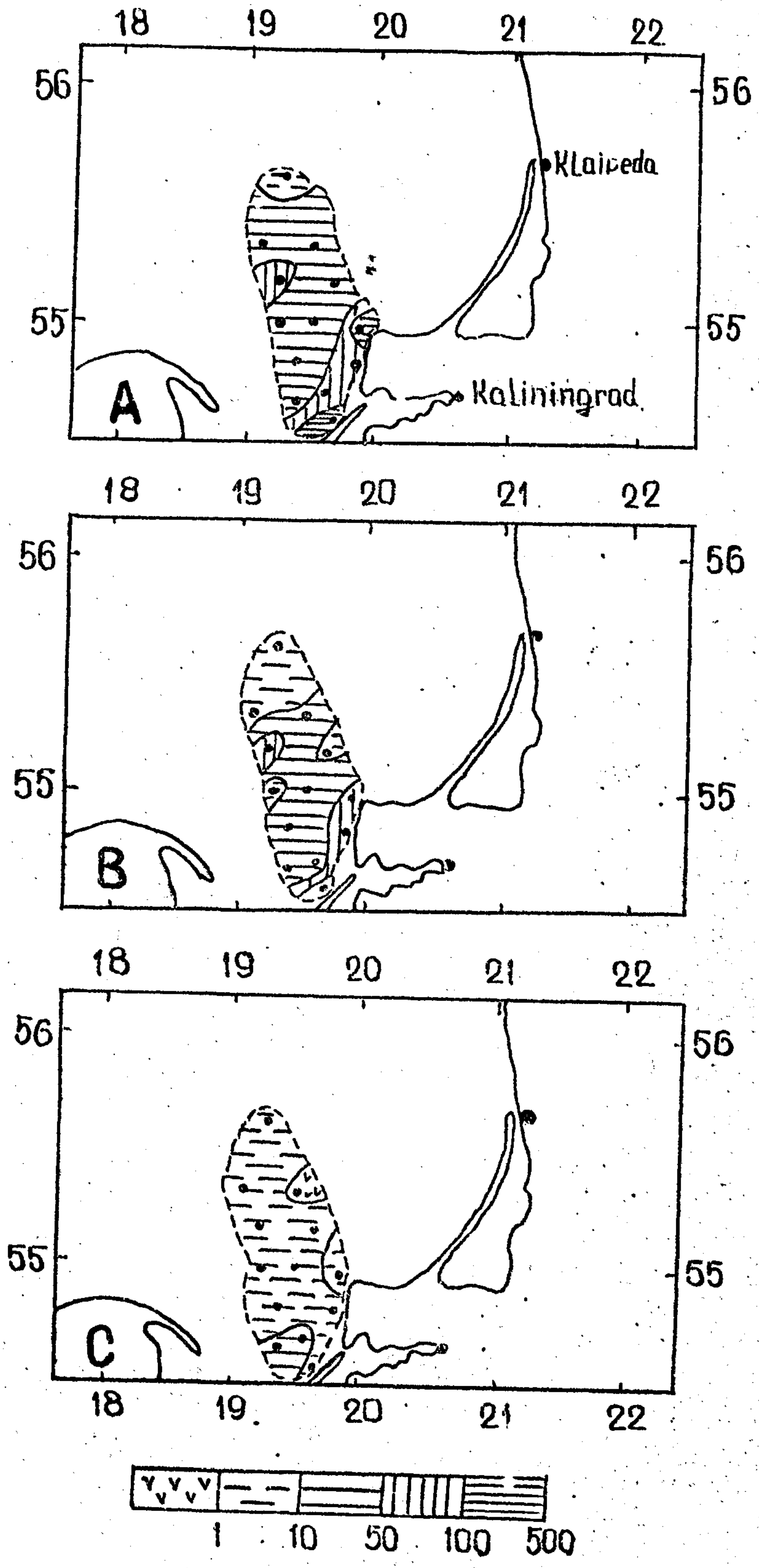


Fig.5

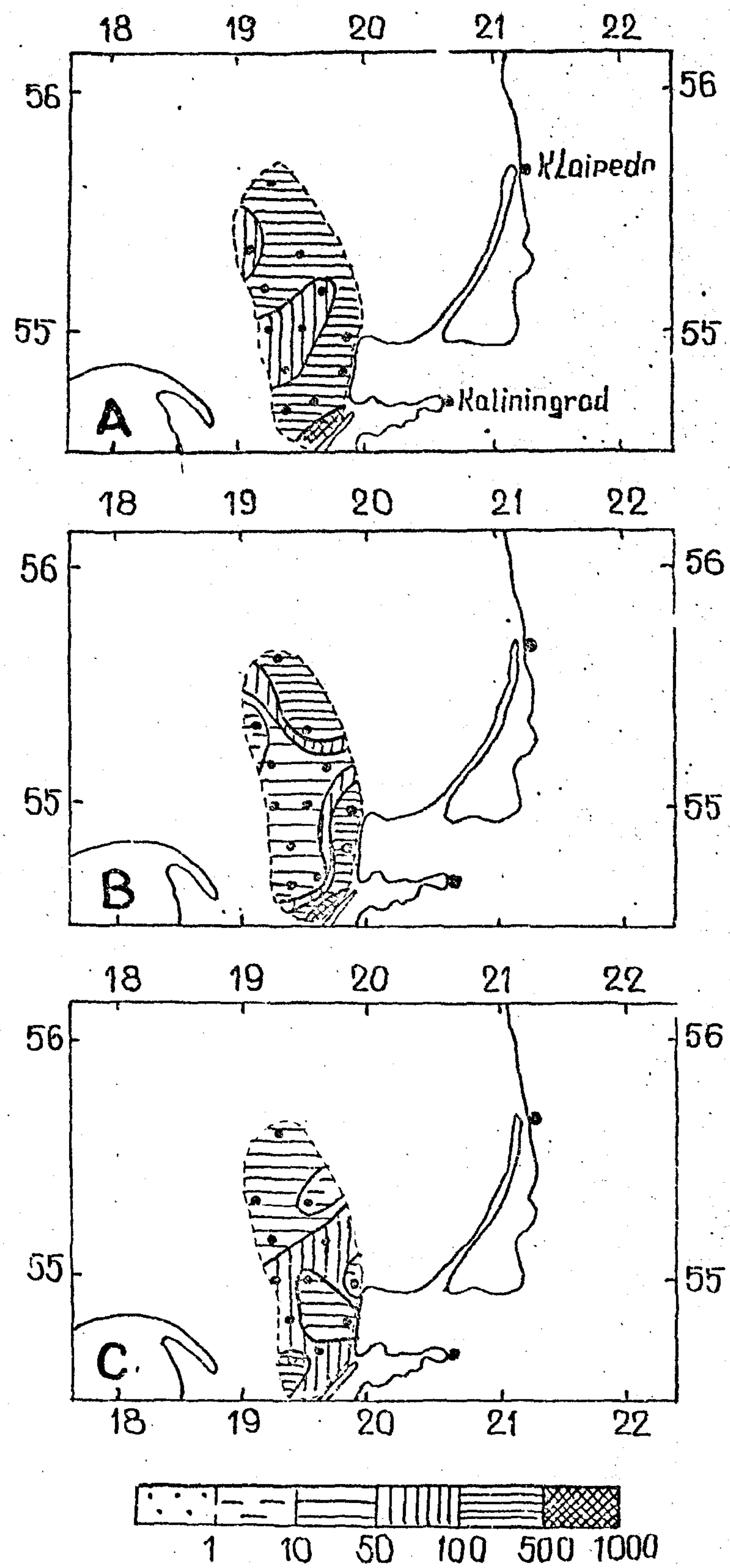

18
19
20
21
22
56
55
Klaipeda
Kaliningrad
A
B
C
1
10
50
100
500
1000

Fig.6

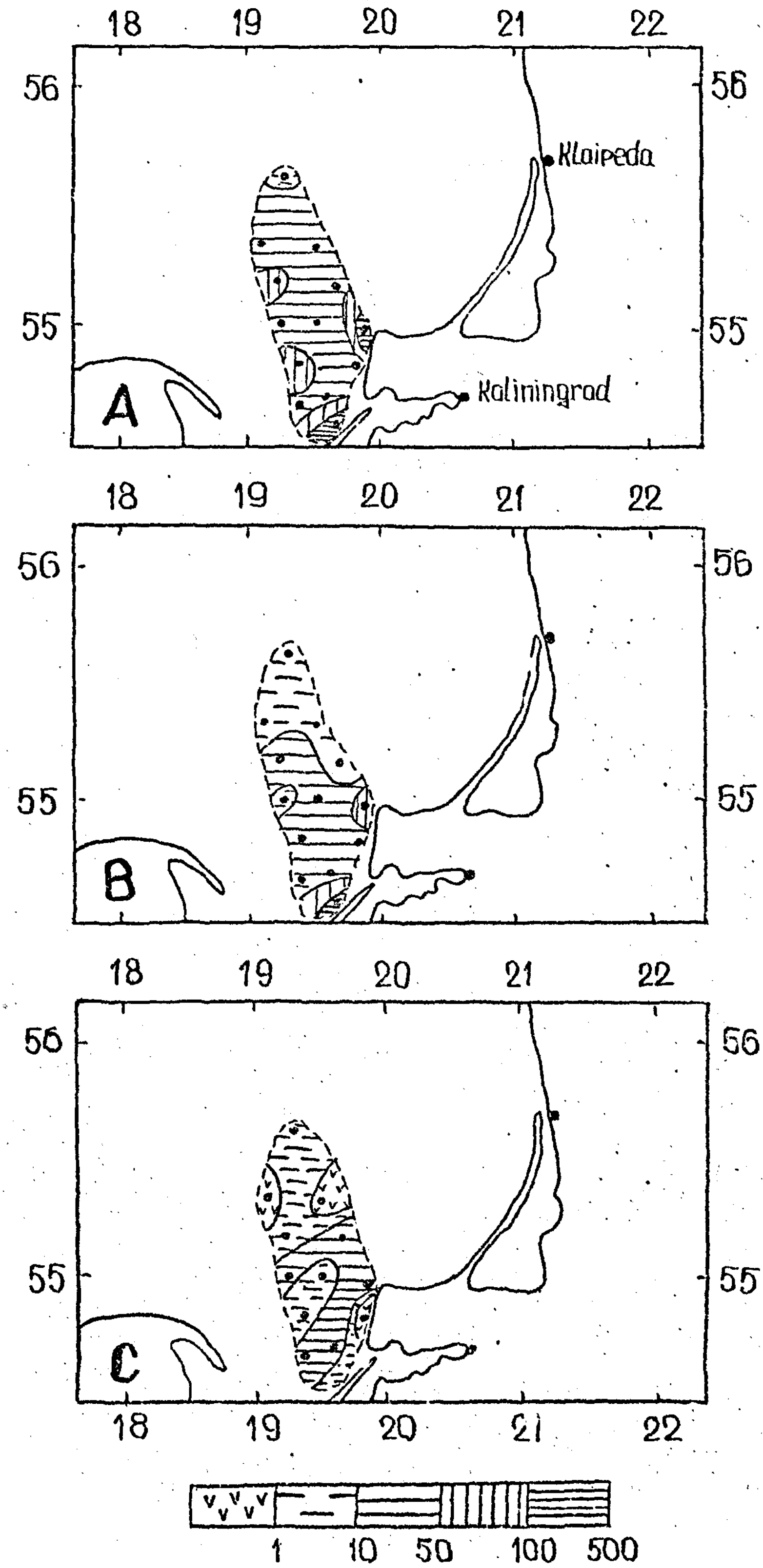


Fig.7

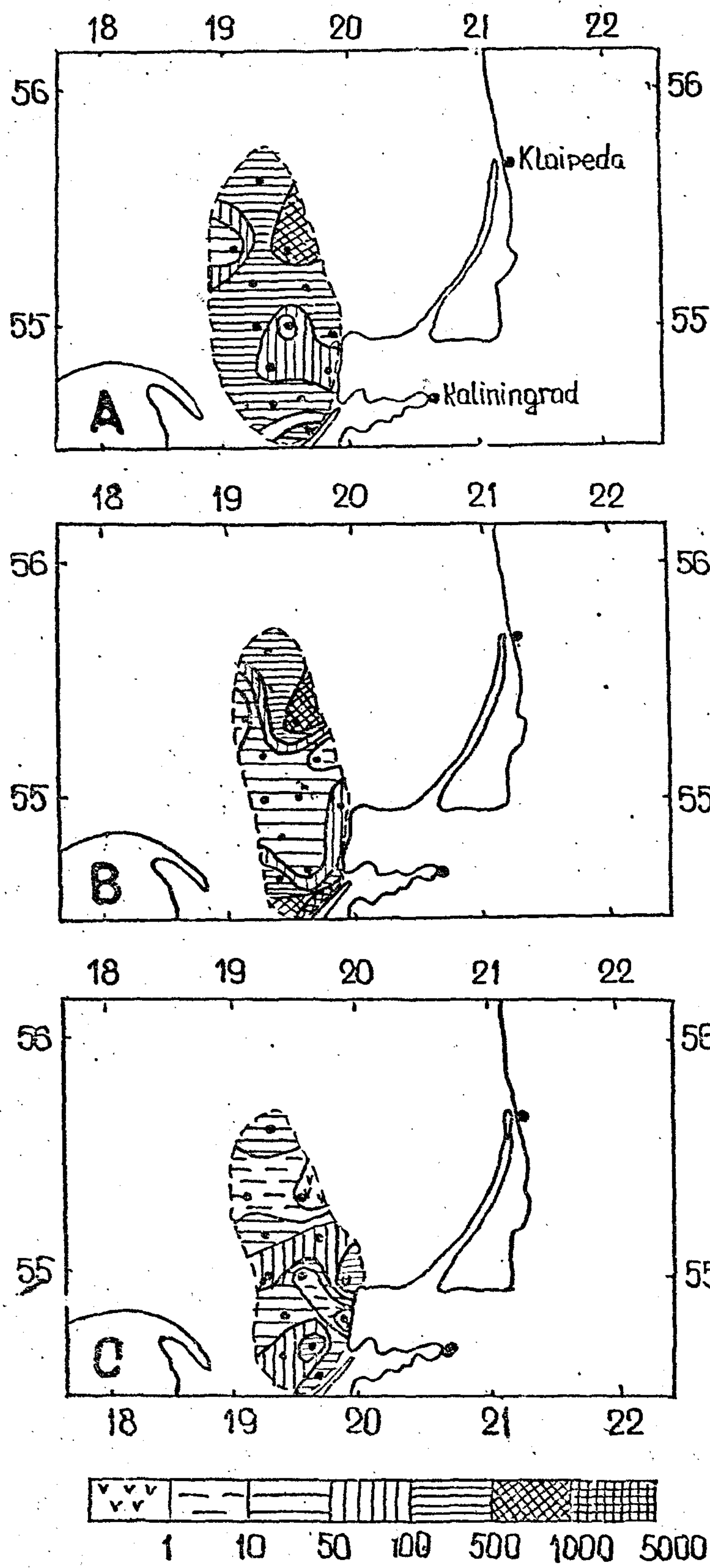

18
19
20
21
22
56
55
Klaipeda
Kaliningrad
A
B
C
1
10
50
100
500
1000
5000

Fig.8